FORM PTO-1390 (REV. 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: MAF0001.US

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): 10/018298

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP00/04139	9 May 2000	18 June 1999

TITLE OF INVENTION: METHOD FOR CONDUCTING CRASH TESTS USING A CARRIAGE AND CORRESPONDING DEVICE

APPLICANT(S) FOR DO/EO/US: Hermann Stefan, et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [ ] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [ ] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is attached hereto (required only if not communicated by the International Bureau).
   b. [ ] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [X] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [X] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [ ] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [X] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [ ] Other items or information:

PCT/RO/101 - English - German
PCT/ISA/210 - English - German

JC05 Rec'd PCT/PTO 14 DEC 2001

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
10/018298	PCT/EP00/04139	MAF0001.US

21. [X] The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1000.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$860.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [X] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ 130.00	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	21 - 20 =	1	x **$18.00**	$ 18.00	
Independent claims	2 - 3 =		x **$80.00**	$ 0.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$270.00**	$ 0.00	
TOTAL OF ABOVE CALCULATIONS =				$ 18.00	
[ ] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.			+	$ 0.00	
SUBTOTAL =				$1,038.00	
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$ 0.00	
TOTAL NATIONAL FEE =				$1,038.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 0.00	
TOTAL FEES ENCLOSED =				$1,038.00	
				Amount to be refunded:	$
				charged:	$

a. [X] A check in the amount of $ 1,038.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 20-0095. A duplicate copy of this sheet is enclosed.

d. [ ] Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:
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Todd T. Taylor
SIGNATURE

Todd T. Taylor
NAME

36,945
REGISTRATION NUMBER

PATENT

THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	)	
Hermann Steffan	)	Group:
Serial No.:	)	
Filed: December 14, 2001	)	
Title: METHOD FOR CONDUCTING CRASH	)	Examiner:
TESTS USING A CRASH-TEST CARRIAGE	)	
AND A CORRESPONDING APPARATUS	)	
THEREFOR	)	

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Please enter the following Amendment to the application prior to calculating the filing fee.

Attached hereto as "ATTACHMENT A" is a marked-up copy showing the changes made to the above-identified patent application by the present Amendment.

IN THE SPECIFICATION

Please replace the current specification with the substitute specification attached hereto.

IN THE ABSTRACT

Please delete the abstract in its entirety and replace therefor the abstract attached hereto.

IN THE CLAIMS

Please cancel claims 1-20.

Please add the following new claims 21-41:

21. (New) A method of conducting crash tests using a crash-test carriage, said crash-test carriage being accelerated in accordance with a real deceleration curve to thereby simulate deceleration forces associated with a real collision, said crash-test carriage having a carriage drive apparatus associated therewith, the method comprising the steps of:

exerting an accelerating force on said crash-test carriage in an acceleration direction, said accelerating force exceeding a respective force required for acceleration in accordance with the real deceleration curve; and

exerting a braking force on said crash-test carriage in a direction opposite said acceleration direction in order to achieve a desired acceleration curve, said braking force being applied on one of said crash-test carriage and said carriage drive apparatus, said braking force being so large so as to accelerate said crash-test carriage in accordance with the desired acceleration curve.

22. (New) The method of claim 21, wherein a collision of a motor vehicle with an obstacle is simulated.

23. (New) The method of claim 21, wherein said braking force is regulated in a manner dependent upon the real acceleration of said crash-test carriage.

24. (New) The method of claim 21, wherein said accelerating force is generated pneumatically.

25. (New) The method of claim 24, wherein said crash-test carriage has a pressure-generating source associated therewith, said pressure-generating source comprising a pressure chamber, the method further including the steps of:

generating in the pressure chamber, at a maximum braking force, a pressure that corresponds at least to a maximum required acceleration force; and

subsequently gradually reducing said braking force in accordance with the desired acceleration curve.

26. (New) The method of claim 25, wherein said pressure chamber has a pressure sensor associated therewith for measuring the pressure therein, said generating of said pressure being controlled via said pressure sensor.

27. (New) The method of claim 25, further including the step of lowering the pressure in said chamber to ambient pressure at an end of said crash test.

28. (New) The method of claim 21, wherein said braking force is hydraulically transmitted to one of said crash-test carriage and said carriage drive apparatus.

29. (New) The method of claim 21, further including the step of emergency braking of said carriage drive apparatus at an end of said crash test.

30. (New) The method of claim 29, wherein said end of said crash test is determined based upon at least one of a path covered by said crash-test carriage, a length of time associated with said crash test and a speed of said crash-test carriage.

31. (New) An apparatus for conducting crash tests using a crash-test carriage, said crash-test carriage being accelerated in accordance with a real deceleration curve to thereby simulate deceleration forces associated with a real collision, said crash-test carriage having a carriage drive apparatus associated therewith, the apparatus comprising:

a pressure-generating source having a pressure chamber associated therewith, said pressure chamber having a chamber volume;

a piston located within said pressure-generating source, said piston restricting said chamber volume;

a thrust rod positioned within said pressure-generating source opposite said chamber volume, said thrust rod being operatively coupled with said piston, said thrust rod being configured for acting upon said crash-test carriage;

a compressor for generating a required pressure in said pressure chamber; and

a brake device configured for acting upon one of said crash-test carriage and said thrust rod.

32. (New) The apparatus of claim 31, further including a safety valve operatively connected with said pressure chamber, said safety valve restricting a maximum pressure within said pressure chamber.

33. (New) The apparatus of claim 31, further including a pressure sensor operatively connected to said pressure chamber, said pressure sensor producing an output pressure signal, said output pressure signal being used to control pressure generation within said pressure chamber.

34. (New) The apparatus of claim 32, further including a pressure switch operatively connected with said pressure chamber, said pressure switch having a switch response pressure associated therewith, said safety valve having an associated valve response pressure, said switch response pressure being less than said valve response pressure, said pressure switch being operatively coupled with said compressor, said pressure switch being configured for switching off said compressor when said pressure within said pressure chamber is equal to at least said switch response pressure.

35. (New) The apparatus of claim 31, further including a hydraulic unit coupled with said brake device, said brake device being hydraulically actuated by said hydraulic unit.

36. (New) The apparatus of claim 35, further including a hydraulic valve associated with said brake device and said hydraulic unit, said hydraulic valve being configured for regulating a braking force generated by said brake device.

37. (New) The apparatus of claim 21, wherein said braking device generates a braking force, said braking force being regulated in a manner dependent upon an acceleration of said crash-test carriage.

38. (New) The apparatus of claim 21, wherein said braking device generates a braking force, said braking force being regulated in a manner dependent upon a desired brake pressure of

said brake device.

39. (New) The apparatus of claim 21, wherein said thrust rod loosely engages said crash-test carriage, said thrust rod thereby being configured for displacing said crash-test carriage.

40. (New) The apparatus of claim 21, wherein said brake device configured for acting upon said thrust rod.

41. (New) The apparatus of claim 21, wherein one said compressor and a corresponding said pressure chamber together comprise an acceleration unit, at least one said acceleration unit being provided for generating a required acceleration force.

REMARKS

In compliance with MPEP § 608.01(q), Applicants submit that no new matter has been added in the substitute specification attached hereto. Applicants have included a marked-up copy of the original specification, the changes indicated therein corresponding to the changes implemented in the substitute specification.

In the event Applicants have overlooked the need for an extension of time, an additional extension of time, payment of fee, or additional payment of fee, Applicants hereby conditionally petition therefor and authorize that any charges be made to Deposit Account No. 20-0095, TAYLOR & AUST, P.C.

Should any question concerning any of the foregoing arise, the Examiner is invited to telephone the undersigned at (219) 897-3400.

Respectfully submitted,

Jeffrey T. Knapp
Registration No. 45,384

Agent for Applicant

JTK/tj

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Enc.: Return postcard

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patents, Washington, DC 20231, on: December 14, 2001.

Jeffrey T. Knapp, Reg. No. 45,384
Name of Registered Representative

Signature

December 14, 2001
Date

PATENT

Title: METHOD FOR CONDUCTING CRASH TESTS USING A CRASH-TEST CARRIAGE AND A CORRESPONDING APPARATUS THEREFOR
Application Serial No.: Group: Examiner:

ATTACHMENT A:
MARKED-UP COPY SHOWING AMENDMENTS

IN THE SPECIFICATION

Attached herewith is a mark-up copy of the specification.

IN THE CLAIMS

Please cancel claims 1-20.

Please add the following new claims 21-41:

21. (New) A method of conducting crash tests using a crash-test carriage, said crash-test carriage being accelerated in accordance with a real deceleration curve to thereby simulate deceleration forces associated with a real collision, said crash-test carriage having a carriage drive apparatus associated therewith, the method comprising the steps of:

exerting an accelerating force on said crash-test carriage in an acceleration direction, said accelerating force exceeding a respective force required for acceleration in accordance with the real deceleration curve; and

exerting a braking force on said crash-test carriage in a direction opposite said acceleration direction in order to achieve a desired acceleration curve, said braking force being applied on one of said crash-test carriage and said carriage drive apparatus, said braking force being so large so as to accelerate said crash-test carriage in accordance with the desired acceleration curve.

22. (New) The method of claim 21, wherein a collision of a motor vehicle with an obstacle is simulated.

23. (New) The method of claim 21, wherein said braking force is regulated in a manner dependent upon the real acceleration of said crash-test carriage.

24. (New) The method of claim 21, wherein said accelerating force is generated pneumatically.

25. (New) The method of claim 24, wherein said crash-test carriage has a pressure-generating source associated therewith, said pressure-generating source comprising a pressure chamber, the method further including the steps of:

generating in the pressure chamber, at a maximum braking force, a pressure that corresponds at least to a maximum required acceleration force; and

subsequently gradually reducing said braking force in accordance with the desired acceleration curve.

26. (New) The method of claim 25, wherein said pressure chamber has a pressure sensor associated therewith for measuring the pressure therein, said generating of said pressure being controlled via said pressure sensor.

27. (New) The method of claim 25, further including the step of lowering the pressure in said chamber to ambient pressure at an end of said crash test.

28. (New) The method of claim 21, wherein said braking force is hydraulically transmitted to one of said crash-test carriage and said carriage drive apparatus.

29. (New) The method of claim 21, further including the step of emergency braking of said carriage drive apparatus at an end of said crash test.

30. (New) The method of claim 29, wherein said end of said crash test is determined based upon at least one of a path covered by said crash-test carriage, a length of time associated with

said crash test and a speed of said crash-test carriage.

31. (New) An apparatus for conducting crash tests using a crash-test carriage, said crash-test carriage being accelerated in accordance with a real deceleration curve to thereby simulate deceleration forces associated with a real collision, said crash-test carriage having a carriage drive apparatus associated therewith, the apparatus comprising:

a pressure-generating source having a pressure chamber associated therewith, said pressure chamber having a chamber volume;

a piston located within said pressure-generating source, said piston restricting said chamber volume;

a thrust rod positioned within said pressure-generating source opposite said chamber volume, said thrust rod being operatively coupled with said piston, said thrust rod being configured for acting upon said crash-test carriage;

a compressor for generating a required pressure in said pressure chamber; and

a brake device configured for acting upon one of said crash-test carriage and said thrust rod.

32. (New) The apparatus of claim 31, further including a safety valve operatively connected with said pressure chamber, said safety valve restricting a maximum pressure within said pressure chamber.

33. (New) The apparatus of claim 31, further including a pressure sensor operatively connected to said pressure chamber, said pressure sensor producing an output pressure signal, said output pressure signal being used to control pressure generation within said pressure chamber.

34. (New) The apparatus of claim 32, further including a pressure switch operatively connected with said pressure chamber, said pressure switch having a switch response pressure associated therewith, said safety valve having an associated valve response pressure, said switch response pressure being less than said valve response pressure, said pressure switch being operatively coupled with said compressor, said pressure switch being configured for switching off said compressor when said pressure within said pressure chamber is equal to at least said switch response pressure.

35. (New) The apparatus of claim 31, further including a hydraulic unit coupled with said brake device, said brake device being hydraulically actuated by said hydraulic unit.

36. (New) The apparatus of claim 35, further including a hydraulic valve associated with said brake device and said hydraulic unit, said hydraulic valve being configured for regulating a braking force generated by said brake device.

37. (New) The apparatus of claim 21, wherein said braking device generates a braking force, said braking force being regulated in a manner dependent upon an acceleration of said crash-test carriage.

38. (New) The apparatus of claim 21, wherein said braking device generates a braking force, said braking force being regulated in a manner dependent upon a desired brake pressure of said brake device.

39. (New) The apparatus of claim 21, wherein said thrust rod loosely engages said crash-test carriage, said thrust rod thereby being configured for displacing said crash-test carriage.

40. (New) The apparatus of claim 21, wherein said brake device configured for acting upon said thrust rod.

41. (New) The apparatus of claim 21, wherein one said compressor and a corresponding said pressure chamber together comprise an acceleration unit, at least one said acceleration unit being provided for generating a required acceleration force.

METHOD FOR CONDUCTING CRASH TESTS USING A CRASH-TEST CARRIAGE AND A CORRESPONDING APPARATUS THEREFOR

BACKGROUND OF THE INVENTION

1. Field of the invention.

The present invention relates to a method for conducting crash tests using a carriage, in particular for simulating the collision of a motor vehicle with an obstacle, in which the deceleration forces of a real collision are simulated. The invention moreover relates to an apparatus for carrying out such a method.

2. Description of the related art.

When a vehicle collides with a resistance, for example another vehicle, in an accident, it is decelerated in accordance with the deformability of each of the vehicle and the resistance (e.g., the other vehicle). This deceleration initiates an acceleration onto the movable masses of the vehicle. In order to be able to investigate these acceleration forces, it is known to conduct real crash tests in which a vehicle is accelerated to a desired speed and collides with an obstacle. The vehicle is, however, destroyed thereby and cannot be used for further crash tests.

To allow acceleration forces to be investigated in accidents without having to destroy a whole vehicle for this purpose, so-called crash tests using a carriage are conducted, in which a carriage is accelerated to the desired speed, for example by a pre-stressed elastic cable. The carriage then collides with a deformable obstacle at this speed. However, with this kind of test, it is difficult to recreate deceleration curves from real crash tests.

It is therefore also known to simulate the deceleration of a real crash test by an acceleration of the test object. This means that the acceleration forces acting on the movable masses of the vehicle on collision with an obstacle are exerted directly via an acceleration of the crash-test carriage onto the test object. Real deceleration curves can thus be recreated substantially better.

In known methods, in order to conduct such tests, the carriage is accelerated by a thrust rod which is hydraulically moved out of a cylinder tube in accordance with a real deceleration curve. In order to recreate the real deceleration curve, the hydraulic pressure exerted on the thrust rod is controlled by a hydraulic valve. In view of the high degree of acceleration required, this thrust rod must be capable of being actuated at an extremely high rate and must be able to react very quickly. A plurality of calibration tests must be conducted for the adaptation to the real deceleration curve since such a valve cannot be regulated within the test time of a maximum of 100 milliseconds. This process is therefore relatively expensive and time-consuming.

SUMMARY OF THE INVENTION

The present invention provides a method for conducting crash tests using a carriage with which real deceleration curves can likewise be recreated very precisely, but which is less expensive and time-consuming, and includes an apparatus for carrying out such a method.

According to the present invention, during the test, a first force is exerted on the crash-test carriage in the direction of acceleration, this first force being larger than a respective second force required for acceleration in accordance with the real deceleration curve, on the one hand. In order to achieve the desired acceleration curve, a braking force opposite to the direction of acceleration is exerted on the crash-test carriage or on an apparatus driving it, this braking force being so large that the resulting force accelerates the carriage in accordance with the desired acceleration curve, on the other hand.

The generation of acceleration and the adaptation of the acceleration to a desired curve can be advantageously separated from one another by the exertion of an acceleration force on the crash-test slide, on the one hand, and of a braking force, on the other hand. The adaptation is thereby possible with a relatively low effort. In particular, a regulation can be carried out. Time-consuming calibration tests are thereby made superfluous so that the method overall requires

much less effort than the one described with respect to the related art and, nevertheless, allows a very exact adaptation to the desired acceleration curve.

In accordance with an embodiment of the invention, the force acting in the direction of acceleration is produced pneumatically. It is possible to pneumatically generate a force in a simple manner and allows, likewise in a simple manner, a repeated conducting of crash tests using a carriage.

In accordance with a further embodiment of the invention, a pressure is generated in a pressure reservoir at a maximum braking force, the pressure corresponding at least to the maximum required acceleration force, and, subsequently, the brake is gradually opened in accordance with the acceleration curve. In this way, the adaptation of the acceleration to the acceleration curve can be achieved solely by a controlled or regulated opening of the brake. This adaptation is, in particular, of advantage when carrying out a real-time regulation.

In accordance with a further embodiment of the invention, the generation of the required pressure is controlled via a pressure sensor arranged in the pressure reservoir, in particular by using a computer. In this way, the exact pressure generation is ensured in the pressure reservoir.

In accordance with a further embodiment of the invention, the braking force is hydraulically transferred onto the brake carriage or onto an apparatus driving it. An exact control and regulation is thus possible in a particularly easy manner. As a result of the relatively low amount of hydraulic fluid required, valves with a comparatively low flow rate, in particular standard hydraulic valves, can be used, which can also be regulated in real time.

In accordance with a further embodiment of the invention, an emergency braking of an apparatus driving the crash-test carriage is carried out at the end of the crash test using a carriage, with the end of the crash test preferably being determined via the path covered, the time and/or

the speed of the crash-test carriage. The exertion of an uncontrolled force on the crash-test carriage after the end of the test is thus prevented.

An apparatus for conducting the method includes, in accordance with the invention, a pressure chamber whose volume is restricted by a piston which acts on the crash-test carriage via a thrust rod; a compressor for generating the required pressure in the pressure chamber; and a braking device for acting on the crash-test carriage or on the thrust rod. Crash tests using a carriage in accordance with the invention can thus be conducted in an advantageous manner with pneumatic acceleration.

In accordance with a further embodiment of the invention, the pressure chamber has a safety valve to restrict the maximum pressure. Damage to the system due to excess pressure is thereby avoided.

In accordance with a further embodiment of the invention, a pressure sensor is present in the pressure chamber whose output signal is transmitted to a control unit to control the pressure generation. The achieving of the required pressure in the pressure chamber is thus ensured.

In accordance with a further embodiment of the invention, a pressure switch is provided in the pressure chamber whose response pressure lies somewhat below the safety valve pressure. Upon reaching the response pressure, the pressure switch switches off the compressor. The compressor is thus automatically switched off before the maximum permitted pressure is reached, and the occurrence of excess pressure is avoided.

In accordance with a further embodiment of the invention, the brake device acting on the crash-test carriage or on the thrust rod can be hydraulically actuated. This hydraulic actuation is advantageous for construction and allows a control, and in particular a regulation, of the braking force. A standard hydraulic valve is preferably provided for this purpose.

In accordance with a further embodiment of the invention, the braking force can be regulated dependent on the acceleration of the crash-test carriage. An acceleration sensor is provided therefor which measures the acceleration of the crash-test carriage. Another possibility includes regulating the braking force dependent on the desired pressure of the hydraulic brake.

In accordance with a further embodiment of the invention, the crash-test carriage can be displaced by a thrust rod, the thrust rod engaging loosely at the carriage, with the brake device preferably acting on the thrust rod. This set-up is advantageous for construction and also allows the crash-test carriage to roll out at the end of the test.

In accordance with a further embodiment of the invention, a plurality of units are provided in order to generate the acceleration force. The force required to accelerate the crash-test carriage can thereby be generated more simply.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawing, wherein:

Fig. 1 is a side view of a crash-test carriage system of the invention.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplification set out herein illustrates one preferred embodiment of the invention, in one form, and such exemplification is not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the sole drawing, Fig. 1, a compressor 1 generates, in a compressed air tube 2, an air pressure required for conducting a crash test using a carriage. A safety valve 3 ensures that a maximum pressure is not exceeded in compressed air tube 2.

A pressure sensor 4 is connected to compressed air tube 2 and measures the actual pressure in compressed air tube 2. This measurement is forwarded to a control computer (not shown here). When the desired pressure is reached, the control computer initiates the switching off of compressor 1. In addition, a pressure switch 5 can be connected to compressed air tube 2, the response pressure of pressure switch 5 lying somewhat below the response pressure of safety valve 3. When pressure switch 5 responds, compressor 1 is switched off. Finally, a rotary valve 6 is connected to compressed air tube 2, and the pressure in compressed air tube 2 can be lowered to ambient pressure thereby.

A thrust rod 7 is inserted into compressed air tube 2 and has a piston 8 at its inner end which is sealingly guided in compressed air tube 2 and thereby limits compressed air volume V in compressed air tube 2. The other end of thrust rod 7 loosely engages at a crash-test carriage 9. Crash-test carriage 9 can be displaced on rails 10 in the direction of longitudinal axis I of thrust rod 7. The starting position of crash-test carriage 9 is determined by a stop 11. Furthermore, an acceleration sensor 12 is provided on crash-test carriage 9, and the acceleration of crash-test carriage 9 in the direction of arrow II can be measured thereby and transmitted to the control computer.

A hydraulically actuable brake device 13 engages at thrust rod 7. The flow of hydraulic fluid 15 from a hydraulic unit 15 to brake device 13 is regulated via a servo valve 14. Moreover, a pressure sensor 16 is present at brake device 13. Pressure sensor 16 measures the brake pressure and transmits a related signal to the control device/computer.

To conduct a crash test using a carriage, servo valve 14 is first fully opened so that brake device 13 is closed, and thrust rod 7 is held at its starting position at which crash-test carriage 9 contacts stop 11. Now, the required pressure is built up in compressed air tube 2 via compressor 1. When the test starts, servo valve 14 begins to regulate the braking force on thrust rod 7 in accordance with a desired acceleration curve. The actual acceleration of crash-test carriage 9 is measured directly via acceleration sensor 12 and is used in the control computer to regulate the braking force. Alternatively, the braking force can be measured via brake pressure sensor 16, and the braking force can be regulated dependent on the brake pressure.

As soon as at least one of the termination criteria, path covered, time and/or speed of crash-test carriage 9, has been satisfied, servo valve 14 opens fully again so that an emergency braking of thrust rod 7 is initiated. Crash-test carriage 9 thereby lifts off of thrust rod 7 and rolls out on rails 10. For the next test, carriage 9 and thrust rod 7 are pushed back into the starting position at which carriage 9 contacts stop 11.

The conducting of the crash test using a carriage 9 can be carried out in a particularly suitable manner with this arrangement, with a very precise adaptation to a real acceleration curve being achieved by the separation of the generation of the acceleration force and the adaptation of the acceleration to a desired acceleration curve via brake device 13. The pneumatic generation of the acceleration force and the use of hydraulic brake device 13 are in this respect advantageous, in particular, for a repeated conducting of the crash test using carriage 9.

While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present

disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

Reference numeral list

1	compressor
2	compressed air tube
3	safety valve
4	pressure sensor
5	pressure switch
6	rotary valve
7	thrust rod
8	piston
9	crash-test carriage
10	rails
11	stop
12	acceleration sensor
13	brake device
14	servo valve
15	hydraulic unit
16	brake pressure sensor
I	longitudinal axis of 7
II	direction of acceleration
V	compressed air volume

ABSTRACT OF THE DISCLOSURE

A method of conducting crash tests uses a crash-test carriage. The crash-test carriage is accelerated in accordance with a real deceleration curve to thereby simulate deceleration forces associated with a real collision, the crash-test carriage having a carriage drive apparatus associated therewith. The method includes the step of exerting an accelerating force on the crash-test carriage in an acceleration direction, the accelerating force exceeding a respective force required for acceleration in accordance with the real deceleration curve. The method also includes a step of exerting a braking force on the crash-test carriage in a direction opposite the acceleration direction in order to achieve a desired acceleration curve. The braking force is applied on one of the crash-test carriage and the carriage drive apparatus, the braking force being so large so as to accelerate the crash-test carriage in accordance with the desired acceleration curve.

Method for conducting crash tests using a carriage and corresponding apparatus

The present invention relates to a method for conducting crash tests using a carriage, in particular for simulating the collision of a motor vehicle with an obstacle, in which the deceleration forces of a real collision are simulated by accelerating a crash-test carriage in accordance with the real deceleration curve. The invention moreover relates to an apparatus for carrying out such a method.

When a vehicle collides with a resistance, for example another vehicle, in an accident, it is decelerated in accordance with the deformability of the vehicle and the resistance. This deceleration initiates an acceleration onto the movable masses of the vehicle. In order to be able to investigate these acceleration forces, it is known to conduct real crash tests in which a vehicle is accelerated to a desired speed and collides with an obstacle. The vehicle is, however, destroyed thereby and cannot be used for further crash tests.

To allow acceleration forces to be investigated in accidents without having to destroy a whole vehicle for this purpose, so-called crash tests using a carriage are conducted, in which a carriage is accelerated to the desired speed, for example by a pre-stressed elastic cable. The carriage then collides with a deformable obstacle at this speed. However, with this kind of test, it is difficult to recreate deceleration curves from real crash tests.

It is therefore also known to simulate the deceleration of a real crash test by an acceleration of the test object. This means that the acceleration forces acting on the movable masses of the vehicle on collision with an obstacle are exerted directly via an acceleration of the crash-test carriage onto the test object. Real deceleration curves can thus be recreated substantially better.

In known methods, in order to conduct such tests, the carriage is accelerated by a thrust rod which is hydraulically moved out of a cylinder tube in accordance with a real deceleration curve. In order to recreate the real deceleration curve, the hydraulic pressure exerted on the thrust rod is controlled by a hydraulic valve. In view of the high required acceleration, this must have an extremely high flow rate and must be able to react very quickly. A plurality of calibration tests must be conducted for the adaptation to the real deceleration curve since such a valve cannot be regulated within the test time of a maximum of 100 milliseconds. This process is therefore relatively expensive and time-consuming.

It is the underlying object of the invention to provide a method for conducting crash tests using a carriage with which real deceleration curves can likewise be recreated very precisely, but which is less expensive and time-consuming. Furthermore, an apparatus for carrying out such a method is to be set forth.

This object is satisfied in that during the test, a force is exerted on the crash-test carriage in the direction of acceleration, which is larger than

the respective force required for acceleration in accordance with the real deceleration curve, on the one hand, and that in order to achieve the desired acceleration curve, a braking force opposite to the direction of acceleration is exerted on the crash-test carriage or on an apparatus driving it, which is so large that the resulting force accelerates the carriage in accordance with the desired acceleration curve, on the other hand.

The generation of acceleration and the adaptation of the acceleration to a desired curve can be advantageously separated from one another by the exertion of an acceleration force on the crash-test slide, on the one hand, and of a braking force, on the other hand. The adaptation is thereby possible with a relatively low effort. In particular, a regulation can be carried out. Time-consuming calibration tests are thereby made superfluous so that the method overall requires much less effort than the one described above and nevertheless allows a very exact adaptation to the desired acceleration curve.

In accordance with an embodiment of the invention, the force acting in the direction of acceleration is produced pneumatically. This is possible in a simple manner and allows, likewise in a simple manner, a repeated conducting of crash tests using a carriage.

In accordance with a further embodiment of the invention, a pressure is generated in a pressure reservoir at maximum braking force, said pressure corresponding at least to the maximum required acceleration force, and subsequently the brake is gradually opened in accordance with the acceleration curve. In this way, the adaptation of the acceleration to the

acceleration curve can be achieved solely by a controlled or regulated opening of the brake. This is in particular of advantage when carrying out a real-time regulation.

In accordance with a further embodiment of the invention, the generation of the required pressure is controlled via a pressure sensor arranged in the pressure reservoir, in particular by using a computer. In this way, the exact pressure generation is ensured in the pressure reservoir in a skilled manner.

In accordance with a further embodiment of the invention, the braking force is hydraulically transferred onto the brake carriage or onto an apparatus driving it. An exact control and regulation is thus possible in a particularly easy manner. As a result of the relatively low amount of hydraulic fluid required, valves with a comparatively low flow rate, in particular standard hydraulic valves, can be used, which can also be regulated in real time.

In accordance with a further embodiment of the invention, an emergency braking of an apparatus driving the crash-test carriage and loosely engaging at this is carried out at the end of the crash test using a carriage, with the end of the crash test using a carriage preferably being determined via the path covered, the time and/or the speed of the crash-test carriage. The exertion of an uncontrolled force on the crash-test carriage after the end of the test is thus prevented.

An apparatus for conducting the method comprises, in accordance with the invention, a pressure chamber whose volume is restricted by a piston which acts on the crash-test carriage via a thrust rod, by a compressor for generating the required pressure in the pressure chamber and by a braking device acting on the crash-test carriage or on the thrust rod. Crash tests using a carriage in accordance with the invention can thus be conducted in an advantageous manner with pneumatic acceleration.

In accordance with a further embodiment of the invention, the pressure chamber has a safety valve to restrict the maximum pressure. Damage to the system due to excess pressure is thereby avoided.

In accordance with a further embodiment of the invention, a pressure sensor is present in the pressure chamber whose output signal is transmitted to a control unit to control the pressure generation. The achieving of the required pressure in the pressure chamber is thus ensured.

In accordance with a further embodiment of the invention, a pressure switch is provided in the pressure chamber whose response pressure lies somewhat below the safety valve pressure and which is switched off by the compressor. The compressor is thus automatically switched off before the maximum permitted pressure is reached and the occurrence of excess pressure is avoided.

In accordance with a further embodiment of the invention, the brake device acting on the crash-test carriage or on the thrust rod can be hydraulically actuated. This is advantageous for construction and allows a

control, and in particular a regulation, of the braking force. A standard hydraulic valve is preferably provided for this purpose.

In accordance with a further embodiment of the invention, the braking force can be regulated in dependence on the acceleration of the crash-test carriage. An acceleration sensor is provided for this which measures the acceleration of the crash-test carriage. Another possibility consists of regulating the braking force in dependence on the desired pressure of the hydraulic brake.

In accordance with a further embodiment of the invention, the crash-test carriage can be displaced by means of a thrust rod engaging loosely at the carriage, with the brake device preferably acting on the thrust rod. This is advantageous for construction and also allows the crash-test carriage to roll out at the end of the test.

In accordance with a further embodiment of the invention, a plurality of units are provided in order to generate the acceleration force. The force required to accelerate the crash-test carriage can thereby be generated more simply.

An embodiment of the invention is illustrated in the drawing and will be described in the following. There is shown, in a schematic illustration,

Figure 1 a side view of a crash-test carriage system of the invention.

An air pressure required for conducting a crash test using a carriage is generated in a compressed air tube 2 by a compressor 1, with it being ensured by a safety valve 3 that a maximum pressure is not exceeded in the compressed air tube 2.

A pressure sensor 4 is connected to the compressed air tube 2 and this measures the actual pressure in the compressed air tube 2 and forwards it to a control computer not shown here. When the desired pressure is reached, the control computer initiates the switching off of the compressor 1. In addition, a pressure switch 5 can be connected to the compressed air tube 2 whose response pressure lies somewhat below the response pressure of the safety valve 3. When the pressure switch 5 responds, the compressor 1 is switched off. Finally, a rotary valve 6 is connected to the compressed air tube 2 and the pressure in the compressed air tube 2 can be lowered to ambient pressure by this.

A thrust rod 7 is inserted into the compressed air tube 2 and has a piston 8 at its inner end which is sealingly guided in the compressed air tube 2 and thereby limits the compressed air volume V in the compressed air tube 2. The other end of the thrust rod 7 engages at a crash-test carriage 9 which can be displaced on rails 10 in the direction of the longitudinal axis I of the thrust rod 7. The starting position of the crash-test carriage 9 is determined by a stop 11. Furthermore, an acceleration sensor 12 is provided at the crash-test carriage 9 and the acceleration of the crash-test carriage 9 in the direction of the arrow 2 can be measured by this and transmitted to a control computer not shown here.

A hydraulically actuable brake device 13 engages at the thrust rod 7. The flow of hydraulic fluid 15 from a hydraulic unit 15 to the brake device 13 is regulated via a servo valve 14. Moreover, a pressure sensor 16 is present at the brake device 13 which measures the brake pressure and transmits it to the control device not shown here.

To conduct a crash test using a carriage, the servo valve 14 is first fully opened so that the brake device 13 is closed and the thrust rod 7 is held at its starting position in which the crash-test carriage 9 contacts the stop 11. Now, the required pressure is built up in the compressed air tube 2 via the compressor 1. When the test starts, the servo valve 14 begins to regulate the braking force on the thrust rod 7 in accordance with a desired acceleration curve. The actual acceleration of the crash-test carriage 9 is measured directly via the acceleration sensor 12 and used in the control computer to regulate the braking force. Alternatively, the braking force can be measured via the brake pressure sensor 16 and the braking force be regulated in dependence on the brake pressure.

As soon as at least one of the termination criteria – path covered, time and/or speed of the crash-test carriage 9 – has been satisfied, the servo valve 14 opens fully again so that an emergency braking of the thrust rod 7 is initiated. The crash-test carriage 9 thereby lifts of the thrust rod 7 and rolls out on the rails 10. For the next text, the carriage 9 and the thrust rod 7 are pushed back into the starting position in which the carriage 9 contacts the stop 11.

The conducting of the crash test using a carriage can be carried out in a particularly suitable manner with this arrangement, with a very precise adaptation to a real acceleration curve being achieved by the separation of the generation of the acceleration force and the adaptation of the acceleration to a desired acceleration curve via the brake device 13. The pneumatic generation of the acceleration force and the hydraulic brake device are in this respect advantageous in particular for a repeated conducting of the crash test using a carriage.

Reference numeral list

1	compressor
2	compressed air tube
3	safety valve
4	pressure sensor
5	pressure switch
6	rotary valve
7	thrust rod
8	piston
9	crash-test carriage
10	rails
11	stop
12	acceleration sensor
13	brake device
14	servo valve
15	hydraulic unit
16	brake pressure sensor
I	longitudinal axis of 7
II	direction of acceleration
V	compressed air volume

Claims

1. Method for conducting crash tests using a carriage, in particular for simulating the collision of a motor vehicle with an obstacle, in which the deceleration forces of a real collision are simulated by a crash-test carriage (9) being accelerated in accordance with the real deceleration curve, characterized in that during the test, a force is exerted on the crash-test carriage (9) in the direction of acceleration (II), which is larger than the respective force required for acceleration in accordance with the real deceleration curve, on the one hand, and in that in order to achieve the desired acceleration curve, a braking force opposite to the acceleration direction (II) is exerted on the crash-test carriage (9) or on an apparatus (7) driving it, which is so large that the resulting force accelerates the carriage (9) in accordance with the desired acceleration curve, on the other hand.

2. Method in accordance with claim 1, characterized in that the braking force is regulated in dependence on the actual acceleration.

3. Method in accordance with claim 1 or claim 2, characterized in that the force acting in the direction of acceleration (II) is generated pneumatically.

4. Method in accordance with claim 3, characterized in that, at a maximum braking force, a pressure is generated in a pressure chamber (2) which corresponds at least to the maximum required acceleration force; and in that subsequently the braking force is gradually reduced in accordance with the acceleration curve.

5. Method in accordance with claim 4, characterized in that the generation of the required pressure is controlled via a pressure sensor (4) connected to the pressure chamber (2), in particular by using a computer.

6. Method in accordance with claim 4 or claim 5, characterized in that the pressure in the pressure chamber (2) is lowered to ambient pressure at the end of the crash test.

7. Method in accordance with any one of the preceding claims, characterized in that the braking force is hydraulically transmitted to the brake carriage (9) or to an apparatus (7) driving it.

8. Method in accordance with any one of the preceding claims, characterized in that, at the end of the crash test, an emergency braking of an apparatus (7) driving the crash-test carriage (9) and engaging loosely at this is carried out.

9. Method in accordance with claim 8, characterized in that the end is determined via the path the crash-test carriage (9) covers, by the time and/or by the speed of the crash-test carriage (9).

10. Apparatus for conducting the method in accordance with claim 1 comprising a pressure chamber (2), whose volume (V) is restricted by a piston (8) which acts on the crash-test carriage (9) via a thrust rod (7), a compressor (1) for generating the required pressure in the pressure chamber (2) and a brake device (13) acting on the crash-test carriage (9) or on the thrust rod (7).

11. Apparatus in accordance with claim 10, characterized in that the pressure chamber (2) has a safety valve (3) for restricting the maximum pressure.

12. Apparatus in accordance with claim 10 or claim 11, characterized in that a pressure sensor (4) is connected to the pressure chamber (2) whose output signal is transmitted to a control device to control the pressure generation.

13. Apparatus in accordance with any one of claims 10 to 12, characterized in that a pressure switch (5) is connected to the pressure chamber (2) whose response pressure lies somewhat below the response pressure of the safety valve (3) and by which the compressor (1) is switched off.

14. Apparatus in accordance with any one of claims 10 to 13, characterized in that the brake device (13) acting on the crash-test carriage (9) or on the thrust rod (7) can be hydraulically actuated.

15. Apparatus in accordance with claim 14, characterized in that the braking force can be regulated via a hydraulic valve (14).

16. Apparatus in accordance with claim 15, characterized in that the braking force can be regulated in dependence on the acceleration of the crash-test carriage (9).

17. Apparatus in accordance with claim 14 or claim 15, characterized in that the braking force can be regulated in dependence on the desired pressure of the brake device (13).

18. Apparatus in accordance with claim 17, characterized in that the crash-test carriage (9) can be displaced by means of a thrust rod (7) engaging loosely at the crash-test carriage (9).

19. Apparatus in accordance with claim 18, characterized in that the brake device (13) acts on the thrust rod (7).

20. Apparatus in accordance with any one of claims 10 to 19, characterized in that a plurality of units (1, 2) for generating the acceleration force are provided.

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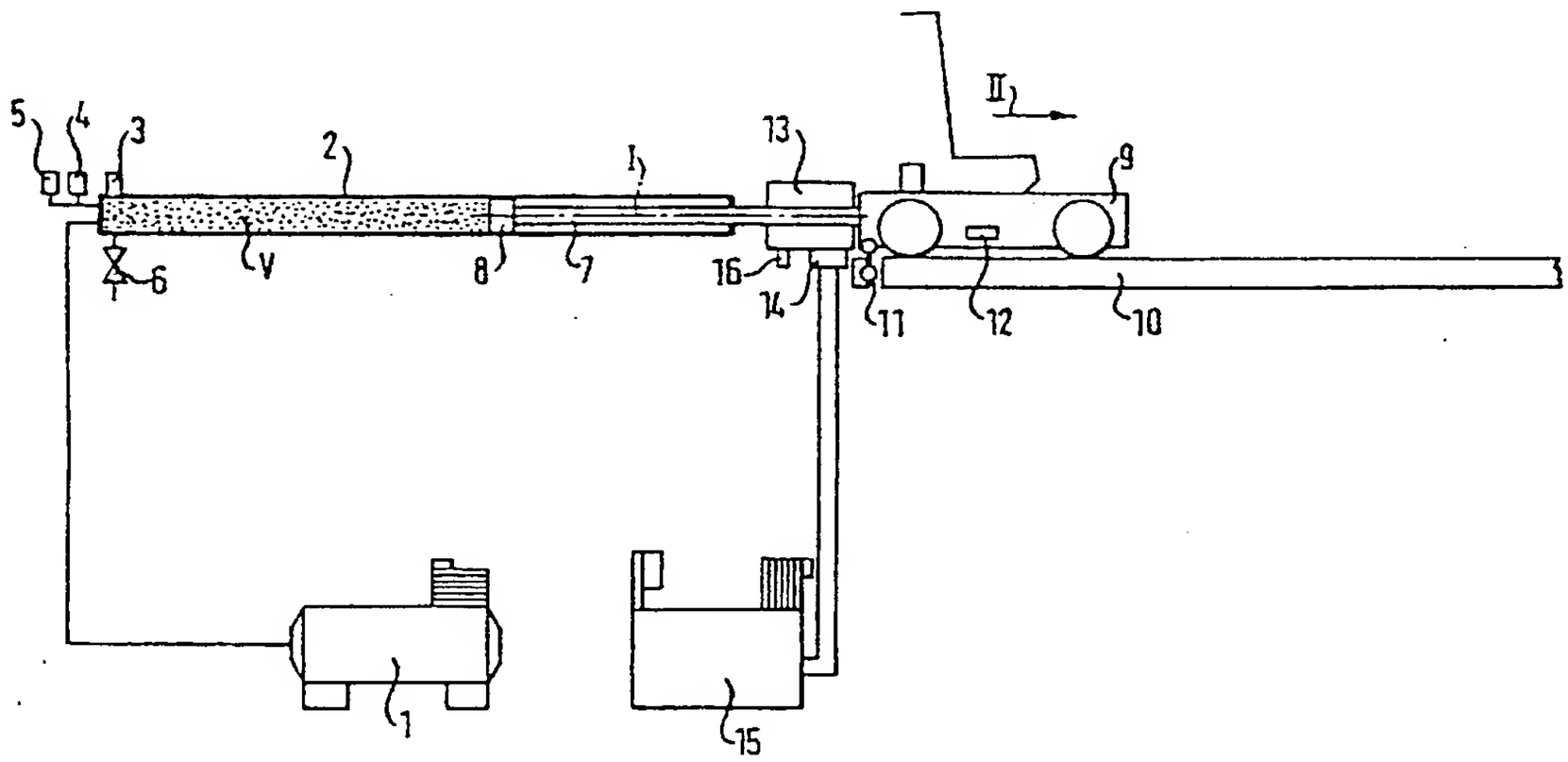
[Fortsetzung auf der nächsten Seite]

(54) Title: METHOD FOR CONDUCTING CRASH TESTS USING A CARRIAGE AND CORRESPONDING DEVICE

(54) Bezeichnung: VERFAHREN ZUR DURCHFÜHRUNG VON CRASH-SCHLITTEN-VERSUCHEN UND VORRICHTUNG HIERFÜR



(57) Abstract: The invention relates to a method for conducting crash tests using a carriage, especially for simulating the collision of a motor vehicle with an obstacle, whereby the deceleration forces of an actual collision are simulated by accelerating a crash-test carriage (9) in accordance with the actual deceleration curve, whereby a force is exerted on the crash-test carriage (9) in the direction of acceleration (II) to avoid calibration tests during the test, said force being greater than the force required for acceleration in accordance with the real deceleration curve. In order to achieve the desired acceleration curve in the crash-test carriage (9) or in a device (7) driving the latter, a brake force is exerted in the direction opposite to the direction of acceleration (II), said force being so great that the resulting force accelerates the carriage (9) in accordance with the desired acceleration curve.

[Fortsetzung auf der nächsten Seite]

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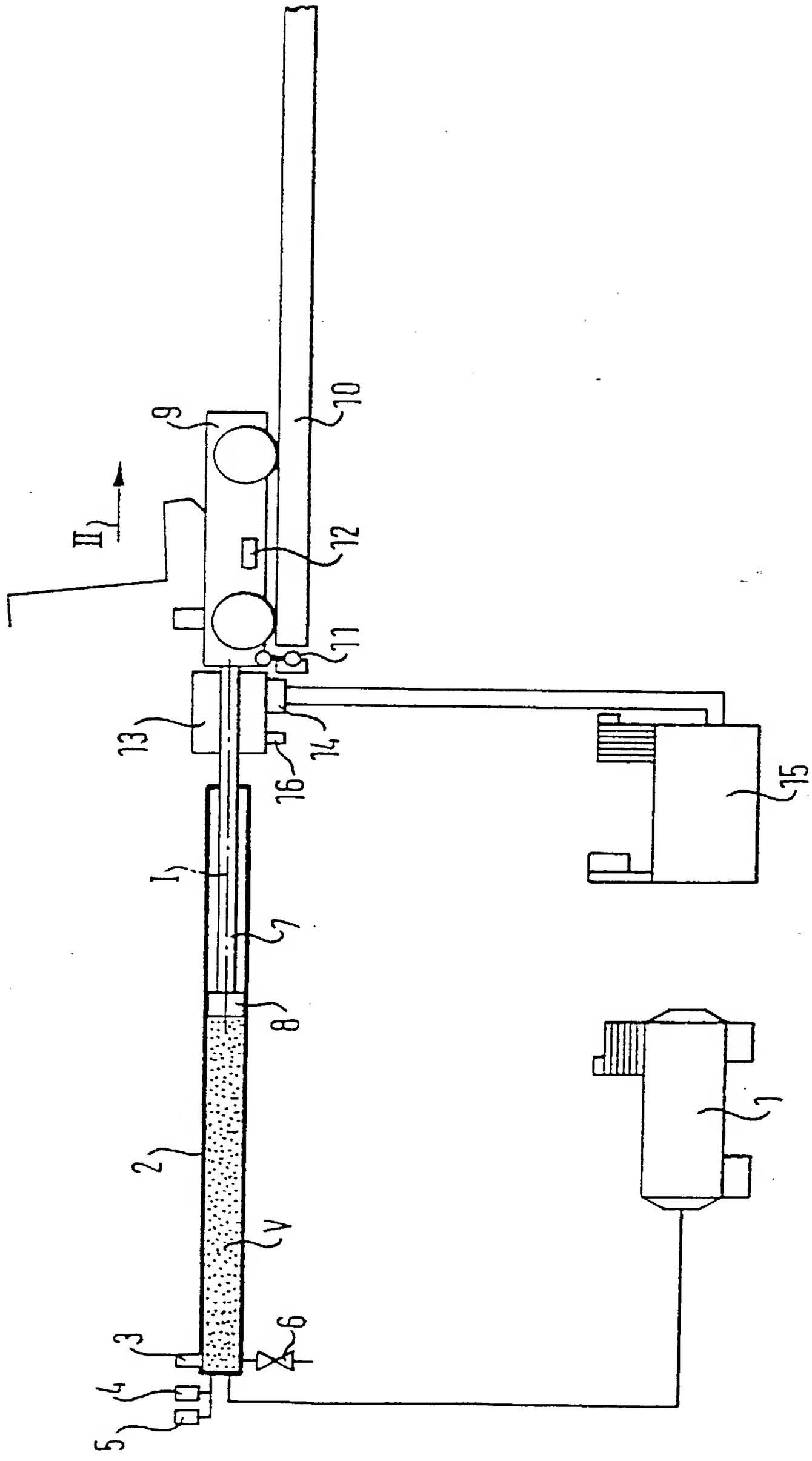
FIG. 1



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PCT/USA NATIONAL DECLARATION AND POWER OF ATTORNEY
FOR U.S. PATENT APPLICATIONS
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER 35 U.S.C. SECTION 371(c)(4)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name:

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the invention described and claimed in international application No. PCT/EP00/04139 entitled: METHOD FOR CONDUCTING CRASH TESTS USING A CRASH-TEST CARRIAGE AND A CORRESPONDING APPARATUS THEREFOR , and as amended on ________________ (if any), which I have reviewed, and I understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above and for which I solicit a patent; that I do not know and do not believe that this invention was ever known or used in the United States of America before my or our invention or discovery thereof, or patented or described in any printed publication in any country before my or our invention or discovery thereof, or more than one year prior to my international application; that this invention was not in public use or on sale in the United States of America for more than one year prior to my international application; that this invention has not been patented or made the subject of an inventor's certificate issued before the date of my international application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months before my international application; that I acknowledge my duty to disclose information of which I am aware which is material to the examination of this application; and that prior to filing said international application, applications for patent or inventor's certificate on this invention of discovery which have been filed by me or my legal representatives or assigns in any country foreign to the United States of America are as follows:

(a) none filed more than 12 months prior to said international application, unless named below:

(b) earliest filed less than 12 months prior to said international application (the priority of which is hereby claimed under 35 U.S.C. Section 365):

DE 199 27 944.6 filed June 18, 1999.

I hereby claim the benefit under Title 35, United States Code, §120, of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a), which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

(Application Serial No.)	(Filing Date)	(Status)(patented, pending, abandoned)

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I declare further that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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